MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER | S | | | | |

INDEX NUMBER | | | | |

Paper 3 Chemistry

October/November 2015

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.
You may use an HB pencil for any diagrams, graphs, tables or rough working.
Write in dark blue or black pen.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section B
Answer any **two** questions.
Write your answers in the spaces provided on the question paper.

A copy of the Data Sheet is printed on page 19.
A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Section A

Answer **all** the questions in the spaces provided.

1 Briefly describe the method you would use and the results you would expect in distinguishing between

(a) a solution of pH 1 and a solution of pH 14,

method .....

result for solution of pH 1 .....

result for solution of pH 14 ..... [1]

(b) the gases ethene and ethane,

method .....

result for ethene .....

result for ethane ..... [1]

(c) an endothermic and an exothermic reaction,

method .....

result for an endothermic reaction .....

result for an exothermic reaction ..... [1]

(d) a solution of sodium chloride and a solution of sodium sulfate.

method .....

result for sodium chloride .....

result for sodium sulfate ..... [1]

2 Most substances can be placed into only **one** of the five groups listed in Table 2.1.

Table 2.1

group	letter
element	**A**
compound	**B**
mixture of elements	**C**
mixture of compounds	**D**
mixture of elements and compounds	**E**

Which of the groups, **A**, **B**, **C**, **D** or **E** in Table 2.1, best describes each of the following substances?

air .....

brass .....

hydrogen .....

sodium carbonate ..... [2]

3 **(a)** When completed, Table 3.1 describes the components of most atoms.
Complete the table by filling in the blank boxes.

Table 3.1

	relative mass	**relative charge**
proton	1	1+
neutron	1	
electron		

[3]

(b) (i) A beryllium ion can be represented as

$$^{9}_{4}Be^{2+}$$

Determine how many protons, neutrons and electrons are present in a single ion of beryllium, Be^{2+}.

number of protons .....

number of neutrons .....

number of electrons ..... [3]

(ii) Write an ionic equation for the formation of a beryllium ion, Be^{2+}, from a beryllium atom.

.....[2]

4 Atoms of non-metallic elements can combine with other atoms to form many different compounds.

(a) One of these compounds, ammonia, is a non-conductor of electricity and has a low melting point.

(i) Name the type of chemical bonding present in ammonia.

.....[1]

(ii) Draw a 'dot and cross' diagram to show the arrangement of electrons in a molecule of ammonia in the space below.

[Proton numbers: H, 1; N, 7]

[2]

(b) Another of these compounds, magnesium chloride, has a high melting point and is a conductor of electricity when molten.

(i) Name the type of chemical bonding present in magnesium chloride.

.....[1]

(ii) Draw a 'dot and cross' diagram to show the arrangement of electrons in magnesium chloride in the space below.

[Proton numbers: Mg, 12; C*l*, 17]

[2]

5 Sodium hydrogencarbonate, $NaHCO_3$, and sodium carbonate, Na_2CO_3, have similar chemical properties.

Sodium hydrogencarbonate can be made in the laboratory by bubbling carbon dioxide through a cold, concentrated solution of sodium carbonate.

$$Na_2CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3$$

(a) The sodium carbonate solution has a concentration of $2.0\,mol/dm^3$.
What volume of this solution contains 500 g of sodium carbonate?

[Relative atomic masses: A_r: C, 12; O, 16; Na, 23]

[2]

(b) Calculate the maximum mass of sodium hydrogencarbonate that can be made from 500 g of sodium carbonate.

[Relative atomic masses: A_r: H, 1; C, 12; O, 16; Na, 23]

[2]

(c) Baking powder consists mainly of sodium hydrogencarbonate and a small quantity of an acidic substance.

When in contact with moisture, the acidic substance reacts with the hydrogencarbonate.

Suggest why moist bread dough, containing baking powder, will rise (expand) when placed in a hot oven.

.....

.....[1]

6 Fig. 6.1 describes some of the properties and reactions of several substances.

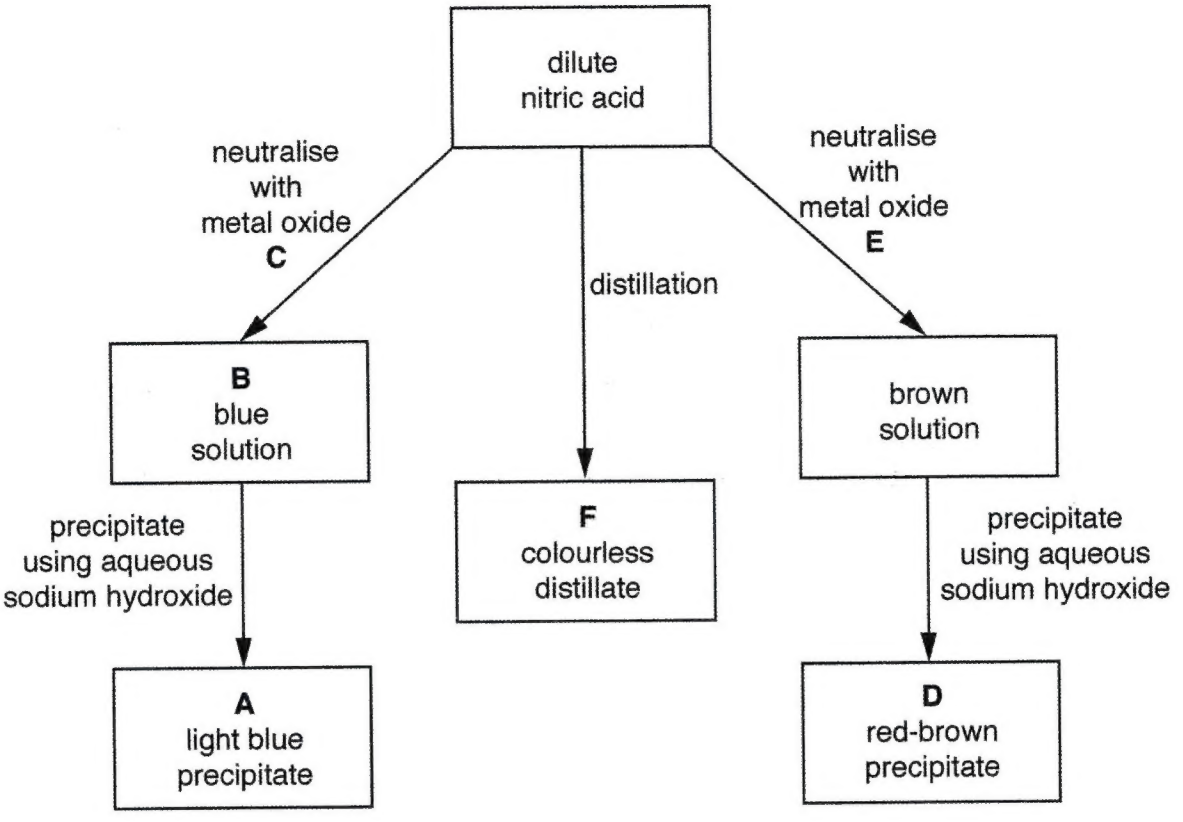

Fig. 6.1

(a) Suggest the identity of substances **A**, **B**, **C**, **D**, **E** and **F**.

A .....

B .....

C .....

D .....

E .....

F .....

[6]

(b) Write a balanced chemical equation for any **one** of the reactions in Fig. 6.1.

.....[2]

7 **(a)** Write the chemical formula for **propane** and calculate its relative molecular mass.

[Relative atomic masses: A_r: H, 1; C, 12]

formula .....

relative molecular mass = ... [2]

(b) **(i)** Calculate the volume of 10 g of **ethane** at room temperature and pressure.

[Relative atomic masses: A_r: H, 1; C, 12]
[The volume of one mole of any gas is 24 dm^3 at room temperature and pressure.]

volume of ethane = ... [2]

(ii) The chemical equation for the **complete** combustion of ethane is as follows:

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

Calculate the volume of oxygen needed to burn 10 g of ethane completely.

volume of oxygen needed = ... [1]

(iii) Calculate the volume of air that contains this volume of oxygen.

Assume that clean air contains exactly 21% oxygen.

volume of air = ... [2]

(c) **(i)** State why **ethene** can be made into a polymer but **ethane** cannot.

.....

.....[1]

(ii) Describe what happens when ethene molecules undergo polymerisation.

.....

.....[2]

(iii) Fig. 7.1 shows the structural formula of part of an addition polymer.

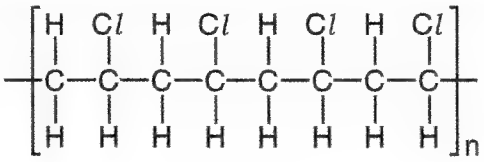

Fig. 7.1

Deduce and draw the structural formula of the monomer from which this polymer is made.

[2]

Section B

Answer any **two** questions in this section.

Write your answers in the spaces provided.

8 The Periodic Table printed on page 20 lists the elements in order of atomic number. Use this Periodic Table to help you answer these questions.

(a) (i) Name any element from Period 2 and explain how the electronic structure of this element can be used to determine which group the element is in.

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.....[3]

(ii) On moving across Period 2 from Group I to Group VII, the character of the elements changes. Describe and explain the change.

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.....[3]

(b) The element with an atomic number of 85 is so unstable that it has never been seen by the naked human eye.

Consider the properties of other elements in the same group as this element. Predict **one** physical property and **one** chemical property of the element with an atomic number of 85.

Write a balanced chemical equation to represent the chemical property that you have described.

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.....[4]

9 **(a)** The speed of a chemical reaction can be changed by

- increasing the pressure of reacting gases,
- decreasing the concentrations of reacting solutions.

(i) State the effect that each of these has on the speed of a reaction.

(ii) Use your knowledge of reacting particles to explain your answer to **(a)(i)**.

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.....[5]

(b) An experiment is to be carried out in the laboratory to measure the average speed of a chemical reaction.

(i) Choose and briefly describe a suitable reaction. Describe the measurements you will make.

(ii) Describe how you will determine the average speed of your reaction. State the units in which the speed of the reaction can be measured.

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.....[5]

10 Metals can be placed in a reactivity series.
Although carbon is a non-metal, it can also be placed in this reactivity series.
It is placed between magnesium and lead.

(a) Metals are extracted in many different ways. Use the reactivity series, **with examples**, to explain the following

(i) some metals can occur in the ground as the uncombined metal,

(ii) several metals occur as oxides. The metal can be extracted from some of these oxides by heating with carbon. For other oxides, this method cannot be used.

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.....[5]

(b) **(i)** Iron and calcium require different conditions to react with water.
By referring to these reaction conditions, justify the relative positions of iron and calcium in the reactivity series.

(ii) Write a balanced chemical equation for **one** of the reactions you described in **(b)(i)**.

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.....[5]

1. **(a)** method: Dip red and blue litmus papers into each solution and observe the colour change.

result for solution of pH 1: The colour of the blue litmus paper turns red.

result for solution of pH 14: The colour of the red litmus paper turns blue.

EXAM TIP:

A solution of pH 1 is very acidic and will turn blue litmus paper red. A solution of pH 14 is very alkaline and will turn red litmus paper blue. The difference in colour distinguishes between the two solutions.

(b) method: Bubble both gases into different test-tubes containing bromine solution.

result for ethene: The colour of the bromine solution changes from reddish-brown to colourless.

result for ethane: No change in colour is observed.

EXAM TIP:

The addition of bromine is used to distinguish between an alkane and an alkene.

(c) method: Use a thermometer to measure the temperature before and after each reaction.

result for an endothermic reaction: The temperature will decrease.

result for an exothermic reaction: The temperature will increase.

EXAM TIP:

How the temperature changes in a reaction tells us whether it is an endothermic or an exothermic reaction.

(d) method: Add acidified aqueous silver nitrate to each solution.

result for sodium chloride: A white precipitate of silver chloride is formed.

result for sodium sulfate: No precipitate formed.

EXAM TIP:

The reaction between the solution and sodium chloride solution, and between the solution and sodium sulfate solution must give different observations in order to distinguish between the two solutions.

2.

air	**E**
brass	**C**
hydrogen	**A**
sodium carbonate	**B**

EXAM TIP:

An element is a substance that cannot be broken down into simpler substances through any chemical or physical means. A compound is a substance that contains two or more elements which are chemically combined in a fixed ratio. A mixture consists of two or more substances that are mixed together.

3. **(a)**

	relative mass	relative charge
proton	1	1+
neutron	1	**0**
electron	$\frac{1}{1840}$	**1–**

(b) **(i)** number of protons: 4

number of neutrons: 5

number of electrons: 2

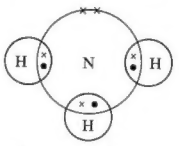
EXAM TIP:

The charge 2+ indicates that the beryllium atom lost 2 electrons to form Be^{2+}.

(ii) $Be(s) \rightarrow Be^{2+}(aq) + 2e^-$

4. **(a)** **(i)** Covalent bonding

(ii)



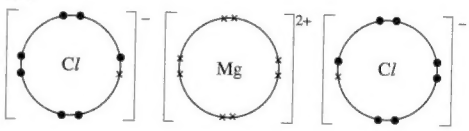
× electron of N
• electron of H

EXAM TIP:

Covalent bonds are formed between non-metal atoms and are formed by sharing of electrons between atoms.

(b) **(i)** Ionic bonding

(ii)



× electron of Mg
• electron of Cl

EXAM TIP:

Ionic bonds are formed by electron transfer, where metal atoms donate electrons to non-metal atoms.

5. **(a)** Number of moles of sodium carbonate in 500 g

$$= \frac{500}{2(23) + 12 + 3(16)}$$

$= 4.7170$ mol (to 5 s.f.)

Volume of sodium carbonate

$$= \frac{4.7170}{2.0}$$

$= 2.36$ dm^3 (to 3 s.f.)

EXAM TIP:

First, find the number of moles of sodium carbonate in 500 g using Number of moles = $\frac{\text{Mass}}{\text{Molar mass}}$. Then, find the volume of sodium carbonate using

Volume = $\frac{\text{Number of moles of sodium carbonate}}{\text{Concentration of sodium carbonate}}$.

(b) Number of moles of Na_2CO_3 in 500 g

$= 4.7170$ mol

Since 1 mole of Na_2CO_3 reacts to form 2 moles of $NaHCO_3$, Number of moles of $NaHCO_3$

$= 4.7170 \times 2$

$= 9.434$ mol

Maximum mass of $NaHCO_3$

$= 9.434 \times [23 + 1 + 12 + 3(16)]$

$= 792$ g (to 3 s.f.)

EXAM TIP:

Use the mole ratio provided by the balanced equation to find the number of moles of sodium hydrogencarbonate. Then, calculate its mass using

Mass = Number of moles of solute × Molar mass.

(c) Acidic substance dissolves in water to give H^+ ions. The H^+ ions react with sodium hydrogencarbonate to form carbon dioxide, causing the bread dough to rise.

6. **(a)** **A** copper(II) hydroxide, $Cu(OH)_2$

B copper(II) nitrate, $Cu(NO_3)_2$

C copper(II) oxide, CuO

D iron(III) hydroxide, $Fe(OH)_3$

E iron(III) oxide, Fe_2O_3

F water

EXAM TIP:

The formation of light blue precipitate A indicates the presence of copper(II) ion (Cu^{2+}); the formation of red-brown precipitate D indicates the presence of iron(III) ion (Fe^{3+}).

(b) Any one of the following:

$CuO(s) + 2HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + H_2O(l)$

$Cu(NO_3)_2(aq) + 2NaOH(aq) \rightarrow Cu(OH)_2(s) + 2NaNO_3(l)$

$6HNO_3(aq) + Fe_2O_3(s) \rightarrow 2Fe(NO_3)_3(aq) + 3H_2O(l)$

$Fe(NO_3)_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3NaNO_3(aq)$

7. **(a)** formula: C_3H_8

relative molecular mass: $3(12) + 8(1) = 44$

EXAM TIP:

The general formula of alkanes is C_nH_{2n+2}.

(b) **(i)** Relative molecular mass of ethane

$= 2(12) + 6(1) = 30$

Number of moles of ethane in 10 g

$$= \frac{10}{30}$$

$$= \frac{1}{3} \text{ mol}$$

Volume of ethane gas at r.t.p.

$$= \frac{1}{3} \times 24$$

$= 8$ dm^3

EXAM TIP:

Volume (dm^3) = number of moles × molar volume

(ii) 7 moles of oxygen is needed to burn 2 moles of ethane completely.

Volume of oxygen needed = $\frac{7}{2} \times 8$

$= 28$ dm^3

EXAM TIP:

Use the mole ratio provided by the balanced equation to find the volume of oxygen needed.

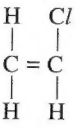
(iii) Volume of air required = $\frac{28}{21} \times 100\%$

$= 133$ dm^3 (to 3 s.f.)

(c) **(i)** Ethene is an unsaturated molecule and possesses a double bond. As such, ethene can undergo addition polymerisation to form a polymer. Ethane is unable to undergo polymerisation as it is fully saturated.

(ii) Ethene undergoes addition polymerisation under high temperature and pressure in the presence of a catalyst. The C=C double bonds are broken, and C–C bonds are formed between the monomers.

(iii) Structural formula of monomer:



EXAM TIP:

Identify the repeat unit from the structural formula given.

Section B

8. **(a)** **(i)** Lithium is an element located in Period 2.

It has the electronic structure of 2.1, indicating that it has one valence electron. Thus, it is placed in Group I.

EXAM TIP:

The last number in the electronic configuration of an element tells us the number of valence electrons it has and hence the group in the Periodic Table the element is in.

(ii) Moving across Period 2 from Group I to Group VII, electronegativity increases. The nuclear charge increases and elements are more likely to attract electrons to themselves. Electrical conductivity decreases across the period, with the exception of graphite which remains a good conductor of electricity. The metallic character of elements decreases, i.e. metals are found on the left side of the period and non-metals are found on the right side.

(b) Astatine has an atomic number of 85 and is found in Group VII. As the colour of the elements in Group VII becomes darker down the group, the colour of astatine is likely to be dark. Similar to the elements in Group VII, astatine is likely to be displaced from its salt by a more reactive halogen.

$2NaAt + Cl_2 \rightarrow 2NaCl + At_2$

9. **(a)** **(i)** Increasing the pressure of reacting gases results in an increase in the rate of reaction. When pressure increases, the number of reactant particles per unit volume of the gas increases. This leads to a greater probability of effective collisions between reactant particles, which increases the rate of reaction.

EXAM TIP:

A higher frequency of effective collisions leads to a greater speed of reaction.

(ii) Decreasing the concentrations of reacting solutions results in a decrease in the rate of reaction. When the concentration decreases, the number of reactant particles per unit volume of the solution decreases as well. This leads to a lower probability of effective collisions between reactant particles, leading to a decrease in the rate of reaction.

(b) **(i)** The speed of reaction can be measured by measuring the volume of hydrogen gas produced during the reaction between magnesium and dilute hydrochloric acid. Place a piece of magnesium ribbon in a conical flask containing dilute hydrochloric acid and connect it to a gas syringe. The volume of hydrogen gas produced can be measured over time and a graph can be plotted to measure the rate of reaction.

(ii) To determine the average speed of reaction, the time measurement will commence when the magnesium ribbon is added to the conical flask, until no more hydrogen gas is produced. The experiment can be repeated multiple times to find the average time taken.

The units of measurement should be in cm^3 / min.

10. **(a)** **(i)** Metals that are less reactive are often found as uncombined metals in the ground. An example is gold, the least reactive metal, which can exist as a native metal and mixed chemical compositions are relatively rare.

(ii) Metals that are lower than carbon on the reactivity series, such as zinc, iron and copper, can be extracted from their oxides by heating with carbon. This method cannot be used for metals that are higher than carbon on the reactivity series, such as aluminium. For such metals, they can only be extracted through electrolysis.

(b) **(i)** Calcium reacts vigorously with cold water while iron can only react slowly with steam. This shows that calcium requires a lower temperature to react with water compared to iron, indicating that calcium is a more reactive metal than iron, so calcium is positioned higher in the reactivity series than iron.

EXAM TIP:

The more reactive a metal is, the higher the position of the metal in the reactivity series.

(ii) $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + H_2(g)$

(Other acceptable answer:
$3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$)